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OF

THE ENGINEERING SOCIETY

OF

THE LEHIGH UNIVERSITY.

ISSUED QUARTERLY.

JUNE, 1888.

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ABSTRACT OF PROCEEDINGS.

Thursday, April 26, 1888.—President Davis in the chair at 19:30 o'clock, and 13 members present. Mr. Breckenridge addressed the Society on "The Duty of Pumping Engines," for which a vote of thanks was tendered him. Mr. Turner, '89, read a paper on "Gould's System of Car Heating."

Thursday, May 10, 1888.—Meeting called to order at 19:45 o'clock by Vice-President McClintic, with 16 members present. Prof. Williams addressed the Society on the subject of "Intermediate Shafts in Tunneling," and received a vote of thanks from the Society. Mr. Dravo, '88, read a paper on "Air Brakes."

Thursday, May 24, 1888.—The last meeting of the year was called to order at 19:40 o'clock by Vice-President McClintic, with 18 members present. The reports of the Treasurer and Librarian were received. The following papers were read: "Deflection of the Plumb Line at the Sayre Observatory," by Mr. S. W. Frescoln, '88; "Manufacture of Coke in the Connellsville Coke District," by Mr. J. S. Siebert, '86. The following officers for the ensuing year were elected:

Mr. Josè R. Villalon, '89, *President;* Mr. Lester C. Taylor, '89, *Vice-President;* Mr. A. W. Stockett, '89, *Secretary;* Mr. Charles H. Deans, '89, *Treasurer;* Mr. Charles P. Turner, '89, *Librarian;*

Mr. Augustus T. Throop, '89, Mr. Pearce Atkinson, '89, *Senior Editors;* Mr. Henry S. Jacoby, '77, Mr. George F. Duck, '83, *Alumni Editors.*

CHARLES J. PARKER,
Secretary.

THE MANUFACTURE OF COKE IN THE CONNELLSVILLE COKE DISTRICT.

The Connellsville vein of coking coal is situated in Western Pennsylvania, the towns of Latrobe, in Westmoreland county, and Fairchance, in Fayette county, approximately marking its northern and southern boundaries, its general direction being north and south, with an average width of about 3 miles. Statistics give the total acreage of the Connellsville belt at about 65,000 acres, nearly the whole of which is in the hands of about a dozen corporations.

The vein is known as a 9-foot vein, but 7 feet may be placed as an average workable thickness. The coal is highly bituminous, and, in most cases, easily mined and free from slate. In the majority of mines the entry is effected by a simple drift at or near the outcrop, but in case the coal lies too deep for this recourse is had to either a slope or a shaft. The deepest shaft in this region (that at Leisenring, about 5 miles west of Connellsville,) being but 530 feet deep. It will thus be seen that the mining of this coal is surrounded by very favorable circumstances, it going from the mines direct to the ovens.

The oven in use is of the style known as the "Bee Hive," having a circular wall and a dome roof. They are built of fire brick throughout, and if placed against a hillside built in a single row (see photo.), but in double rows if standing free.

The front of the oven is protected by a wall reaching to the top and having a batter of about 1 inch per foot. The space between the ovens is filled with dirt and tamped solid. The ovens are charged from the top, through a circular opening about 1 foot in diameter, which also serves as an outlet to the smoke, and the coke is drawn out at an opening built in the front of the oven at about 3 feet from the ground. The average dimensions of an oven (see blue print) are: Diameter at bottom, 12 feet; centre height, 7 feet; the walls being carried up straight for about 2½ feet. A track (*T* in tranverse section on print) on which to run the cars

carrying the coal for charging the ovens is laid either on top of the ovens or to one side and completes the arrangement.

The loaded wagons as they come out of the pit are run to a tipple, where the coal is dumped either directly into the charging cars, or larries, or into a bin from which the larries may be filled. Larries are of two kinds, centre or side charge, according to the way in which they discharge the coal into the ovens. The former runs on tracks laid so as to bring the centre of the larry, and therefore its chute, directly over the openings in the ovens; the latter on tracks so laid that the chutes from the larries' sides just reach the ovens conveniently. The former method necessitates a very broad gauge (7 feet), while the latter may be run on standard gauge tracks.

Each oven receives a charge of from 120 to 135 bushels of coal, which is left to burn for 48 hours. In order to avoid the inconvenience which would arise from charging and drawing all the ovens on the same day, they are so charged as to have one set ready for drawing and recharging every day except Sunday. For instance, the ovens which are charged to-day will be drawn and recharged 48 hours hence, and those which were charged yesterday will be drawn and recharged to-morrow. Those ovens charged on Friday and Saturday receive from 150 to 160 bushels of coal, owing to the extra long time they have to burn. In this way the fires are continually kept up in one set, and the heat from these is sufficient to ignite the fresh coal in the others. Before blocking up the door of the ovens the surface of the coal is levelled by means of a long **L**-shaped iron, this being done to aid uniform burning.

After burning 48 or 72 hours, as the case may be, the ovens cease smoking, and a glance into the top would show a glowing, quivering mass; the coal (if I may use the expression) having fairly melted and run together. The bricks and clay with which the opening in the front of the oven was filled, after charging and levelling, having been removed, water is thrown upon the mass by means of a hose with a long iron nozzle attached, causing dense clouds of sulphurous steam to be given off. When cool, the coke is seen to fill the oven like a large cake about 18 inches high, with an uneven surface. The coke drawer now proceeds with a long iron to break the mass and draw the pieces out of the oven, place them in wheelbarrows and load them upon the cars ready for shipment to work out their part in the great iron industries of the country.

The peculiar characteristics which have given to Connellsville coke its enviable reputation are, that it is free from slate and almost so of sulphur, and when used in blast furnaces it shows great sustaining power, i. e., it is porous and burns without caking. The following two analyses of sample coke will illustrate this point more fully.

Fixed Carbon,	90.000	90.100
Volatile Matter,	1.000	0.700
Ash,	8.200	8.400
Sulphur,	0.800	0.800
	100.000	100.000

The condition of the laboring class in this district compares very favorably with that elsewhere. Owing to the softness of the coal digging is easy and requires no peculiar skill, and accidents of a serious nature are few. A good digger will readily earn $2.50 per day of 8 to 10 working hours. A coke drawer can make about the the same wages, but his work is far more disagreeable, as he must work in the smoke and gas of the burning ovens.

The accompanying blue print explains itself, it being a complete working drawing for an oven of the latest and most approved style.

John S. Siebert, '86.

DEFLECTION OF THE PLUMB LINE AT THE SAYRE OBSERVATORY, LEHIGH UNIVERSITY, SOUTH BETHLEHEM, PA.

The following paper is an abstract of a discussion made by the author, of the precise triangulation at Lehigh University. The object of this triangulation was two-fold:

First, to give the students practice in the precise measurement of angles, and, second, to determine geodetically the latitude and longitude of the dome of the Observatory, in order to compare them with the astronomical determinations, and thus determine the deflection of the Plumb Line, if it was appreciable.

Before going further, it must be stated that in all geodetic measurements the earth is regarded as a spheroid. But it is evident that the form of the earth is not an exact spheroid, and hence all geodetic determinations of latitude and longitude will be more or less of an approximation.

The true normal to the earth's surface at any point, or the vertical line in astronomical observations, is the direction of the force of gravity as indicated by the plumb line. In geodetic measurements the normal to the earth's surface, and therefore the vertical line, is the normal to the surface of the spheroid. It is evident that, owing to the want of homogenity in the structure of the earth's crust, these two lines will at no place exactly coincide, and hence that spheroid best represents the true form of the earth in which the probable error of a single plumb line deflection is reduced to a minimum.

Beginning with the earliest determinations, the different measurements made and the results obtained will now be given.

In 1875, Prof. Doolittle made a series of observations with the Zenith Telescope for determining the latitude of the Observatory dome. Sixty pairs of stars were observed, and from the observations the value of the latitude was found to be $40° 36' 23.887''$ $\pm 0.036''$. An account of these observations is given in *Astronomische Nachrichten*, No. 2260, May, 1879. About the same time a series of telegraphic signals were sent between the Bethlehem station and the Observatory at Washington, for the purpose of determining the longitude of the centre of the Observatory dome. The difference in longitude between the Observatory and the station was found by carrying a mean time chronometer between them. A complete account of the observations, methods, etc., can be found in Washington Astronomical Observations, 1875, Appendix I.

The value of the longitude of the Observatory dome was found to be 6 min. 40.19 sec. east of United States Naval Observatory. Longitude of United States Naval Observatory from Greenwich, $77° 03' 1.35''$, and subtracting the difference, we have the longitude of dome of Sayre Observatory from Greenwich$=75° 22' 58.545''$.

In 1880, Prof. Doolittle, by observations on a circumpolar star, determined the azimuth of the Reformed Church, Bethlehem, from the azimuth stone to be $193° 55' 53''$.

The azimuth stone is a stone monument situated near the Observatory, and is one of the triangulation stations subsequently used. This azimuth was not considered very reliable.

In 1885, Prof. Doolittle again determined the latitude of the Observatory dome by observations of the same stars as formerly, and found it to be $40° 36' 23.530'' \pm .051''$. The precision of both

series of observations was about the same, so we conclude that in ten years the latitude changed about 0.4″.

In the Summer of 1885, Prof. Merriman, in connection with the work on the Geodetic Survey of the State of Pennsylvania, occupied the stations Bake Oven and Smith's Gap, and measured the angles to the Reformed Church, Bethlehem, and Packer Hall, Lehigh University Park, South Bethlehem. By solving these triangles the geographical coördinates of *R* and *P* were obtained. They were:

Reformed Church, (*R*)—

Latitude=40° 37′ 16.778″. Longitude=75° 22′ 33.452″.

Packer Hall, (*P*)—

Latitude=40° 36′ 22.256″. Longitude=75° 22′ 43.378″.

In the Fall of 1885 a local stadia survey was made to connect the spires of the Reformed Church and Packer Hall with the Observatory, and from this survey the following results were obtained:

Latitude, Observatory dome O = 40° 36′ 23.00″.

Longitude, Observatory = 75° 22′ 51.59″.

Comparing these values with the astronomical determinations we see there is a discrepancy in latitude of 0.5″, and in longtitude of about 7″.

In the Fall of 1886 a system of triangulation was laid out, and a number of angles accurately measured, but there was not sufficient data obtained to connect the Reformed Church with the Observatory.

In May, 1887, Prof. Doolittle determined the astronomical azimuth from *K*, one of the triangulation stations, to the Reformed Church, and found it to be 169° 39′ 05.7″±3.1″.

In the Fall of 1887, a new system of triangulation was adopted, comprising the permanent stations of the 1886 system, with several others. The necessary angles were measured by the students, and the adjustments made by Prof. Merriman. It was found that in carrying the (1880) azimuth of *A R* through the triangulations to *K R* that there was a discrepancy of about 1 minute between them. However, using both azimuths, and taking the mean, Prof. Merriman, from the coördinates of *R* and *P* found geodetically in in 1885, computed the coördinates of *O*, and found them to be

Latitude, Observatory dome=40° 36′ 22.865″.

Longitude, Observatory dome=75° 22′ 51.503″.

Some of the angles measured in 1887 were not considered very reliable, and, therefore, in the Spring of 1888, all of the angles

were remeasured, readjusted, and a whole recomputation made by the author.

Prof. Doolittle (May, 1888,) also redetermined the azimuth of *A R*, and found it to be 193° 56′ 38.8″.

Comparing this value with the value carried over through the 1888 triangulation from *K R* (1887 azimuth), there was found to exist a discrepancy of only 8″.

Taking the mean of these two azimuths, and performing the computations, the coördinates of *O* were found to be

Latitude *O*=40° 36′ 22.874″.

Longitude *O*=75° 22′ 51.511″.

We can now form the following comparison:

Comparison of the Astronomical and Geodetic Coördinates of Sayre Observatory Dome, South Bethlehem, Pa.

	LATITUDE.	LONGITUDE.
Astronomical (1875), . .	40° 36′ 23.887″.	75° 22′ 58.545″.
Astronomical (1885), .	40° 36′ 23.530″.	
Geodetic (stadia survey) 1885,	40° 36′ 23.02″.	75° 22′ 51.57″.
Geodetic (1887 triangulation),	40° 36′ 22.865″.	75° 22′ 51.503″.
Geodetic (1888 triangulation),	40° 36′ 22.874″.	75° 22′ 51.511″.

Taking the 1888 values as probably the most accurate, we see that the astronomical latitude exceeds the geodetic by 0.656″, and that the astronomical longitude exceeds the geodetic by 7.034″.

Reducing the deflection in longitude to deflection in the plane of the prime vertical by multiplying by the cos. of the latitude, we have the deflection in the plane of the prime vertical=5.34″.

Hence we have at Sayre Observatory, South Bethlehem, Pa.:

The zenith is deflected, in the plane of the Meridian, North 0.656″.

The zenith is deflected, in the plane of the prime vertical, West 5.34″.

In the report of C. A. Shott, of the United States Coast and Geodetic Survey for 1879, may be found a discussion of the wave of plumb line deflection for the Oblique Arc along the Atlantic from Atlanta, Ga., to Calais, Me.

He gives two curves, one representing the deflection of the plumb line in the plane of the Meridian, and the other in the plane of the prime vertical.

By plotting the deflection at Sayre Observatory on them, the deflection in latitude will be found to approximately coincide with

the curve, but in the prime vertical the coincidence is not so exact. As the data from which the curve was derived are rather scant at this place, it seems evident that the curve should be changed somewhat to suit this observed deflection.

SAMUEL W. FRESCOLN, '88.

DEAD AND LIVE LOADS ON MASONRY ARCHES.

The subject of live loads on arches has not generally been taken into consideration in the investigation given in text-books. In Rankine's investigation it is assumed that the live load may be neglected in comparison with the dead weight on the arch-ring, but, since it is known that the live road is sometimes as great as the weight of the arch itself, it seems that the subject should receive more attention than it has heretofore.

As is well known the thickness of the arch-ring is dependent upon empirical formulas, such as Rankine's or Trautwine's. The thicknesses of arch-rings, obtained by these formulas, agree closely with arches, which have in practice withstood the effects of the various loadings.

There are two ways in which a theoretically perfect arch can be constructed, namely, either the curve of the arch must be designed to correspond with the loading, or the loading must be placed to correspond with the curve adopted. These methods can only be employed when the load under consideration is a dead one.

The subject of unsymmetrial loading has been treated by few writers, and its effect on the stability of the arch is little understood. To show the effect produced by partial loading, extending different distances on the arch and the relation of these to uniform loading, the Black Rock Tunnel Bridge has been investigated. This bridge is situated on the Philadelphia & Reading Railroad between Phœnixville and Reading, one mile above Phœnixville. It was built in the year 1836 for a single track railroad bridge, but as traffic increased it was found necessary to make the road double tracked. When this was done, the side walls of the bridge were removed and a double track laid upon it. The structure is built entirely of granite, and consists of four equal segmental arches. The bridge is still in good condition, although it has served its purposc for over half a century. The dimensions

of the arches are: Span, 72 feet; rise of intrados, 16.5 feet; radius of intrados, 47.5 feet; depth of arch-ring, 2.9 feet; number of arch-stones, 63.

In the investigation only 21 joints were considered, every third voussoir forming with the fourth a joint; thus, joints 1 are the joints formed by voussoirs 1 and 2 on each side of the keystone, joints 2 are those formed by the voussoirs 4 and 5 on each side of the keystone. It was assumed that the live load on this bridge equaled 4,000 lbs. per linear foot, or, in other words, that the single span investigated has a live load on it consisting of consolidation locomotives; also, that the 4,000 lbs. is distributed over 8 feet by means of the ties, then the live load on an arch one foot in thickness will be 500 lbs. per linear foot. This 500 lbs., for convenience in computation, was replaced by stone work weighing 165 lbs. per cubic foot. This gives approximately 3 feet as the height of the masonry replacing the live load.

The curves of pressure for the various loadings were found by the graphical method of investigation. The masonry above the arch-ring, and that replacing the live load, was divided by vertical lines drawn from the upper extremity of the eleven joints on each side of the keystone; the object being first to obtain the weight from the crown resting on any joint and the position of the centre of gravity of this weight.

The theory used in this case is that of Scheffler, which maintains that the thrust, developed at the crown, will not exceed the least amount capable of maintaining equilibrium.

The arch was investigated for the following loadings: Unloaded, quarter loaded, half loaded, three-quarters loaded and fully loaded; the load coming on the arch from the right and the thrust being applied at the centre of the middle third. The thrust at the crown is inclined for the three partial loads. Tables will now be formed showing the distances in feet at which the curves of pressure for the various loadings cut the joints from the intrados.

LEFT HALF.

JOINT NUMBER.	1	2	3	4	5	6	7	8	9	10	11
Unloaded	1.50	1.55	1.70	1.80	1.85	1.90	1.80	1.70	1.50	1.30	1.00
Quarter loaded	1.50	1.50	1.55	1.60	1.60	1.60	1.60	1.50	1 37	1 15	1.00
Half loaded	1.30	1.10	1.00	.85	.90	1.00	1.10	1.20	1 20	1 10	1.00
Three-quarter loaded	1 50	1.45	1.40	1.37	1.30	1.20	1.15	1.10	1.10	1.05	1.00

RIGHT HALF.

Joint Number,	1	2	3	4	5	6	7	8	9	10	11
Unloaded	1.50	1.55	1.70	1.80	1.85	1.90	1.80	1.70	1.50	1.30	1.00
Quarter loaded	1.50	1.80	2.00	2.30	2.50	2.60	2.50	2.20	1.90	1.50	1.00
Half loaded	1.50	1.90	2.10	2.30	2.30	2.20	2.00	1.80	1.60	1.30	1.00
Three-quarter loaded	1.50	1.65	1.70	1.80	1.75	1.70	1.50	1.40	1.30	1.20	1.00

The curve of pressure for the arch fully loaded keeps everywhere within the middle third. From an inspection of the above tables it is seen that it also remains in the middle third when the arch is unloaded and three-quarters loaded.

The worst effects are thus seen to be produced on this arch when the live load extends quarter and half over the arch. Of all the loads considered the curve of pressure for the arch quarter loaded departs farthest from the middle third, approaching the extrados within 0.4 of a foot at joint 6 under the load. Now, from the investigation we see that the line of pressure does not everywhere keep within the midde third; it would be quite natural to expect to find some of the joints open, but such is not the case, as seen by an inspection of the bridge. This result can hardly be attributed to the mortar, but to a spandrel thrust not considered in the investigation.

The curves of pressure having been determined, we must find whether the working strength of the stone is over-reached. For the case, where the curve approaches the extrados within 0.4 of a foot, the pressure per square inch equals 545 lbs. Although this is a great pressure the stone is probably in no danger of crushing, and the arch is perfectly stable.

The investigation, however, shows that the live load extending partially over the arch produces the worst condition for stability, and that the live load heretofore neglected is an important factor in determining the curve of pressure.

H. H. McClintic, '88.

THE DEVELOPMENT AND PRACTICE OF FORESTRY IN EUROPE.

Nearly the whole of Europe was once covered with a dense primeval forest. At the beginning of the Christian Era the northern portions were occupied by wild and savage tribes, who lived mainly by war and the chase, and kept their southern neighbor in terror by their frequent inroads. According to the simple cus-

toms of those days every freeman could use as much wood as he needed, and by clearing a plot to cultivate he came into possession of the soil. His right to the cultivated ground being recognized, he soon claimed the adjoining forest, and thus the whole country passed into the hands of the heads of families.

As the country developed, the rulers, in order to assure themselves of good hunting-grounds, declared themselves owners of immense areas of forest. They then proclaimed that these woods should be used for purposes of the chase, and appointed officers to protect them from destruction.

As the people turned their attention to agriculture the forest lands were gradually cleared for cultivation. But little wood was used in constructing the rude huts and boats of the early inhabitants, and a small area supplied all the necessary fuel. In making their clearings the people unwittingly formed the habit of burning the standing timber to get it out of the way, and this prodigal waste continued for generations. In the meantime ship-building and various other industries following in the wake of civilization, together with the fuel required by the constantly increasing population, made such inroads into the forests that the authorities became alarmed. Stringent laws were enacted during the Fourteenth Century making the wanton destruction of forests punishable by the severest death penalties.

But from various causes the forest area continued to diminish, and much land fit for no other purpose was stripped of its trees. Over population, and the consequent demand for agricultural land, has been the most general cause. It is natural that rich, fertile valleys should be devoted to agriculture, as such land is more valuable for that purpose. A forest can be successfully grown on land which would produce no other profitable crop, for the woody portion of a tree, the part removed, is not nearly so rich in nutritive elements, as the leaves, flowers and fruit which are returned to the soil every year. causing it to become richer instead of impoverishing, it as do other crops.

Large areas belonging to the State have been sold from time to time for the benefit of the exchequer, and, coming into possession of the peasantry, the wood has been chopped off for the double purpose of turning it into money and of having the land to cultivate. The following table, showing how the French forests have been swept away during the past century, illustrates how much easier it is to destroy wood than to replace it:

YEAR.	AREA IN ACRES.	PER CENT.
1750,	37,055,000	27
1788,	19,768,000	14.5
1791,	14,961,905	10.9
1881,	20,749,311	15.1

The evil effects of indiscriminate cuttings are apparent in all European countries, but nowhere are they more so than in Dalmatia, Itria and the country about Trieste, which lie on the eastern shores of the Adriatic. These regions were once covered with luxuriant forests, and were noted for their fertile soil and mild, equable climate. They furnished the material for Roman castles and ships, and later the Venetians drew upon them for their supplies of pile and ship-building timber. Dutch and English merchants cut down the few accessible trees that remained, and the inhabitants then completed the job by pasturing their sheep and goats upon the naked land, thus preventing all growth from the roots. The climate has become changeable; landslides and avalanches are of frequent occurrence, with nothing to obstruct their course; the mountain creeks have dried up; and the whole country is known as "The Karst," a term nearly synonymous with Sahara.

Forest fires, which in the United States do so much damage, are well-nigh impossible here. Fires outside of houses, and within about two miles of a forest, are only allowed during a portion of the year, and then permission must be obtained from the proper authorities. When a fire does occur, the person discovering it must give notice to the first householder he reaches, who in turn is bound to inform the mayor of the nearest village. The mayor calls out a posse of men to subdue it, and any person who refuses to assist subjects himself to a heavy penalty.

Among the causes of destruction beyond the control of man are heavy snowfalls, violent winds, lightnings and erosions by sea and rivers. Insects also sometimes destroy considerable tracts.

The proportion of European forest lands is shown by the following table:

	PER CENT.		PER CENT.
Russia,	40	France,	17
Sweden,	34	Greece,	14
Austria,	15	Spain, Belgium and Holland, each	7
Norway,	29.5	Portugal,	5
Germany,	26	The British Isles,	4
Turkey,	22	Denmark,	3.5
Switzerland,	18		

The average of all Europe is 29.5 per cent.

The evils resulting from the destruction of forests were suspected by the Greeks. Fernando Colon, in his "Life of Admiral Almirante," says: "The Admiral ascribed the many refreshing showers to which he was exposed, as long as he sailed along the coast of Jamaica, to the extent and density of the forests which covered the mountains," and remarked that in earlier years the amount of rain on "Madeira, the Canary and Azores Islands was just as large, but that since the trees that spread out their shade over the land had been cut away rain had become more seldom."

It is found that the average yearly temperature is lower in the forest than in the clear, the cooling influence being most noticeable in Midsummer, and very small in Winter.

Prof. Ebermayer gives the relative humidity of the air in forest and on open land, as follows:

	HUMIDITY.		
	Open Land.	In Forest.	Difference.
In Spring	74.96	80.60	5.70
In Summer	71.92	81.20	9.28
In Autumn	82.72	87.94	5.22
In Winter	84.19	89.43	5.44

This difference shows the amount of moisture in the air due to the evaporation of the water held in the forest.

Large forests induce rain by absorbing heat, both from the ground and the air above, which is then colder than the surrounding air, and thus capable of condensing the passing rain-clouds.

Mathieu, a celebrated French scientist, observed that the portion of the rainfall prevented by the trees from reaching the ground, was:

From November to April, . .	13	per cent.
" May to October, . . .	18.8	"
or an average for the year of .	16	"

If then the forests be cut down in any region there is nothing left to hold in check during the rainy season the rush of waters, which pour from the "hard, barren slopes" "as from the roof of a house, burying with mud and rubbles, or sweeping away everything in its path." Instead of the snows of Winter being kept from melting, by the cool atmosphere of the forest, until late in the Spring, there is nothing to prevent it from melting suddenly upon the first approach of warm weather, changing the babbling mountain brook into a roaring torrent, which spreads destruction in the valley below.

On mountain slopes the scorching rays of the sun dry up the

soil, and rain and snow-water carry it down into the valleys; thus depriving the mountains of the accumulated nourishment of centuries, and leaving them barren wastes, a constant menace to the inhabitants of the valleys.

As to the result on the coast, I quote from Mr. Warnar: "By stripping the beaches of their forests in the 17th and 18th Centuries, the sea-coasts have become exposed to all winds and storms. Fields, once fertile, have been transferred into waste sand dunes, and whole villages, whose agricultural people once prospered, have ceased to exist."

In view of all these facts, the governments of the different European States have undertaken a systematic culture of their forest lands, with the objects of preventing a failure in the supply of fuel, and of reclaiming waste lands and mountain slopes, which had become a menace to the neighboring country.

The lack of intelligent overseers was soon felt. This has been remedied by the establishment of a system of forestry schools, all having in view the same general objects, but differing in methods. The same is true of the forestal organizations in the different countries of Europe.

The French, whose system I shall take as typical, have two Schools of Forestry, one to educate the officers of the corps the other to train the guards and subordinates who work under their direction.

The officer's school was established in 1827, at Nancy. "Its faculty includes seven professors and five tutors, and the course of study occupies two years. Candidates for admission must present diplomas as Bachelors of Science, so that the two years at Nancy are designed to add a special course of study to an already liberal education."

On arriving at the school the applicant is examined by a physician, to see that he has no deformity or malformation rendering him unfit for forestry service. Defective eyesight is considered a physical incapacity.

In describing the secondary school and the functions of the forest officers I cannot do better than to quote the concise language of Consul Mason:

"Upon graduating the student receives appointment as 'Garde-General-Stergiaire,' and subsequent promotion in the corps follows the subjoined grades:

	SALARY PER ANNUM.
Garde-General, . . .	$ 400 to $ 500
Deputy Inspector, . . .	600 to 750
Inspector, ...	1,000 to 1,200
Conservateur, ...	2,000 to 2,100
Inspector-General, . .	3,000

"The duties of the higher officers include all those elaborate works of engineering and construction by which dangerous mountain slopes are sustained and strengthened against rain and frost, until the soil can be recreated and fixed by restored vegetation. Of Inspectors-General, the highest grade in the corps, there are eight now in service. A conservateur usually has charge of the forestry of a department, though in regions where the area of forest is small one officer of this grade may have charge of this department, while in districts where the work is difficult and important, as in the Basses-Alps, there may be two conservateurs in a single department."

"The school for subordinates in the forestry corps is at Barres. . . . . The course of studies there occupies likewise two years, but is much more practical and elementary than at Nancy, candidates for admission being required to pass examinations in only the elements of primary education. Upon graduating they are appointed brigadiers or sergeants in the forestry corps. The gardes-forestiers, or privates in the corps, are recruited largely from ex-soldiers, who have shown especial intelligence and fidelity during their years of military service. For the actual labor of preparing and planting the ground laborers are employed in the neighborhood of the work to be performed."

Forest improvement consists primarily in the cutting away of the older trees, the pruning of dry and decaying branches, and in assisting the natural renewals of growth of shoots and self-sown seedlings. The survey of lands, the laying of drains, the opening of ditches, the establishment and care of nurseries, the choice of seeds, and the adaptation and setting of plants and trees, come under works for the improvement of forests.

In determining the distribution of trees for any locality the quality of the soil has some influence, but the principal factor is the climate, which varies with the altitude, latitude, amount and distribution of rainfall, vicinity to the sea, etc. The condition of the soil as regards moisture has also an important bearing.

The forest areas of Europe are owned by the State, the com-

munes, corporations, public institutions and private individuals. I have prepared the following table to show in five countries the amount and percentage of forest owned by each class, and also the total amount of forest, with its percentage of the entire area:

CLASS.	AUSTRIA.		FRANCE.		GERMANY.		ITALY.		SWITZERLAND	
	*Hectares.	Per Cent	Hectares.	Per Cent	Hectares.	Per Cent	Hectares.	Per Cent	Hectares.	Per Cent
State Property.....	952,689	10.3	967,118	10.70	4,546,757	32.7	425,835	4	32,995	4.20
Corporations........					347,757	2.05				
Private Property..	6,977,134	75.6	6,127,398	66.55	6,720,924	48.03	} 9,844,632	96	232,196	29.57
Communal	1,297,238	14.1	2,058,729	22.40	2,109,913	15.2			520.183	66.23
Public Institutions			32,059	0.35	185,987	1.3				
Total forest area and per cent. of entire area	9,227,061	15	9,185,304	17	13,908,398	25.7	10,270,467	36	785,374	18

*One hectare — 2.47 acres.

The State not only controls its own forests, but also those belonging to communities when requested to do so. The rules and regulations are very strict. Taking an example, I find, from Consul Monaghan's report, that in Baden no part must remain uncultivated. "No kind of freedom in the woods or forests is allowed to the people. The cultivation of private woods is allowed to the owner, but he is bound under the law to observe the statutes . . . relating to the cutting, preparing or carrying away of wood from the forest by night. He must have his woods measured and surveyed and the boundaries fully marked and described. Private owners are not allowed to cut down their forests wholly; to destroy or endanger them without permission from the highest authorities so to do."

They must never let their forests fall below a certain standard. Should the owner fail, either by neglect or careless cultivation, the State foresters take possession and place them under proper treatment. In these forests pasturage to cattle is allowed excepting among young trees. Sheep and goats are not allowed.

Generally trees are allowed to stand until they have reached their greatest value. When used for timber they are usually chopped at the following ages: pine and firs, 80 to 100 years; oaks, 120 to 160 years; beech, 100 to 120 years; alders and birches, 40 to 60 years. Leaf trees are often cut for various purposes at 20 to 30 years of age, and oak, when the bark is used for tanning, at 12 to 15 years.

In cutting seed-bearing trees it is customary to leave 25 or 30 trees per acre to reseed the clearing; and, in case the new growth fails to spring up properly, seeds are planted in the vacant places or else young shoots are set out.

A certain section of forest is usually cut away entirely, leaving only the young trees of natural growth standing, but there are often enough of these to fill the place of the old wood. To illustrate, suppose that in a tract containing 160 acres, it be desired to cut the trees when 80 years old. It should be divided, according to this system, into 80 parcels of 2 acres each, one of which would be cut each year. In this way it occurs that the trees of one lot, and one only, arrive at maturity in any given year.

Another system is to select the maturest trees from the entire forest, but it is so much more expensive to market trees scattered all over the forest than by the first method, that it is not practiced in many localities.

As a means of transporting timber from the forests, roads and bridges must be maintained, and are generally the best. On steep, rocky slopes, slides, either of slats or of wire cables, are often resorted to, and in the neighborhood of streams offering no obstructions rafting would be employed. Portable iron tramways have lately been used with very good results.

The cultivation of forests, so far from being an expense to the government, yields a handsome revenue. In order to exhibit the results obtainable under an intelligent management, I have selected four districts in Saxony. From the 72,682 hectares of state forests in this territory, there was felled in the year 1885, 380,074 fest meters, of which 85 per cent. was suitable for timber and used as such.

The gross revenue was as follows:

Wood, ...	M. 5,487,150
Hunting, ...	4,786
Use of open ground, meadows, quarries and turf lands, ...	108,155
	M. 5,600,091

The expenses were as follows:

For inspection and management, inclusive of M. 70,748 for keeping buildings of the forest in good condition, . .	M. 584,371
For forest improvement, cultivating, drainage, etc., ...	310.554
For expenses of felling and all sundry expenses, ...	739,100
	M. 1,634,025

Leaving a net profit of 3,966,066 marks, or over 52 marks per hectare. (1 mark = 23.8 cents, 1 hectare = 2.47 acres.)

The state foresters are instructed to render private owners all possible assistance in the way of advice, and the furnishing of seeds and young trees from the government nurseries either free or at a trifling cost. Bounties are sometimes paid them for reclaiming waste lands.

Altogether, the results attained have been most gratifying. Not only have the forests proved successful from a financial standpoint, but, what is more important, large tracts of barren wastes which threatened to destroy the prosperity, and even the existence of the adjacent farms and villages, have been brought under control, and made to yield a good money return as well as to regulate the extremes of temperature and prevent freshets and excessive droughts.

C. E. RAYNOR, '88.

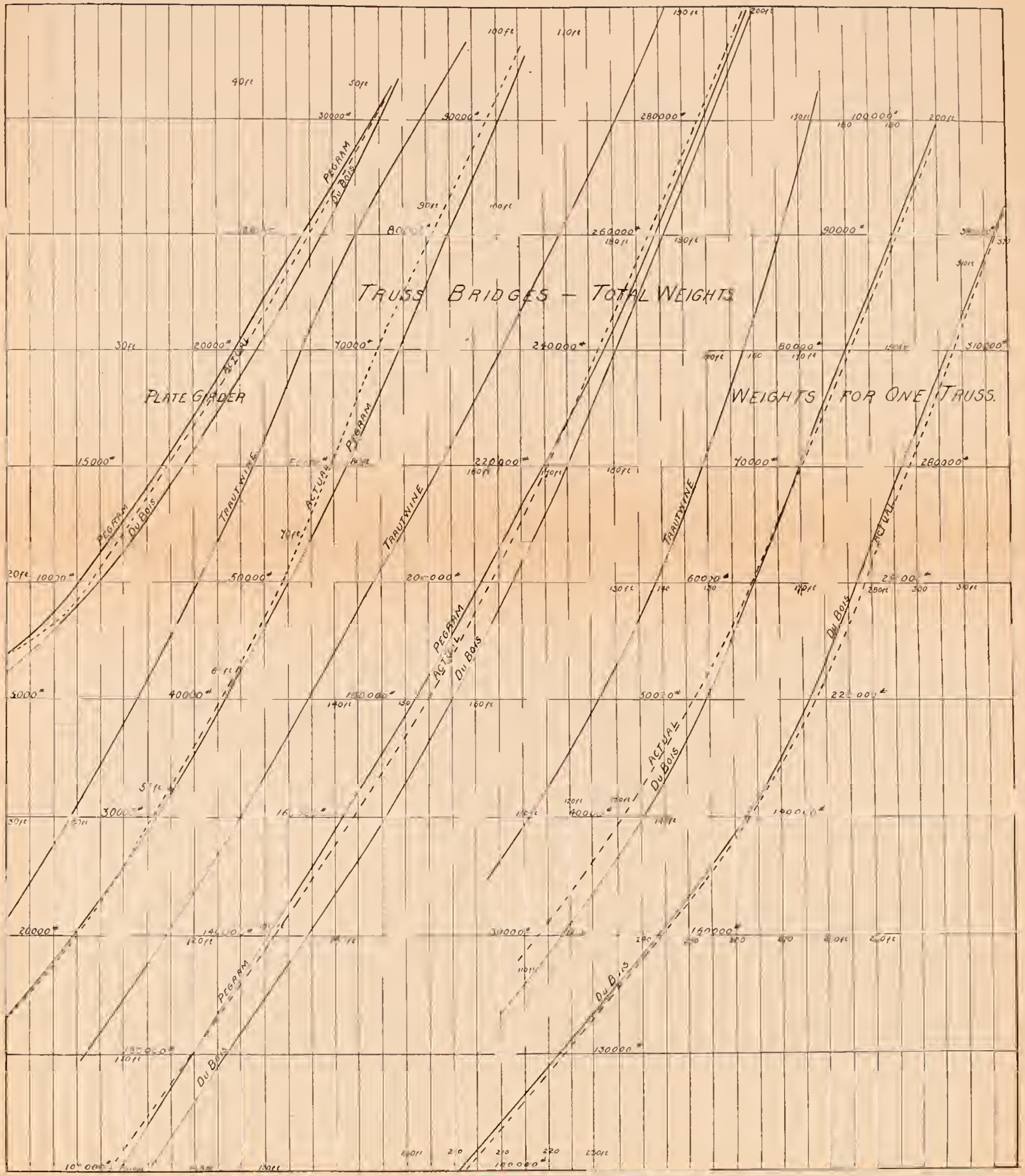
FORMULÆ FOR THE WEIGHTS OF IRON BRIDGES.

In designing a bridge, it is necessary to assume some value for the weight of the trusses, floorbeams, stringers, etc., in order to find the stresses to which the different parts will be subjected. Then after the stresses have been found, the pieces are proportioned according to those stresses and the *actual* weights calculated. If the actual weight of the bridge agrees nearly with that assumed, the dimensions found can be used in the construction of the bridge; otherwise new weights must be assumed and the calculations repeated. The object of the formulæ presented in in this paper is to determine beforehand, by a simple calculation, from certain known conditions of loading, length of span, etc., these weights close enough to make any recalculation unnecessary. Of course the immense variation in the manner of building bridges, the number and position of the pieces, etc., would prevent anything like an accurate mathematical formula, hence the aim in these formulæ has been to deduce such expressions as will give pretty close results for ordinary styles of bridges, not including any pieces that are not absolutely necessary.

Prof. Du Bois's formula:

Let W_1 = equivalent uniform load per foot per truss due to assumed live load system.

W_2 = load per foot per truss due to cross girders, stringers, rails, ties, planking, etc.


TRUSS BRIDGES — TOTAL WEIGHTS
PLATE GIRDER
WEIGHTS FOR ONE TRUSS.
PEGRAM
DU BOIS
ACTUAL
TRAUTWINE

W_3 = load per foot per truss due to wind bracing.

W_4 = weight per foot of one truss, not including bed plates, rollers, and end shoes.

W_2 may be found by assuming 400 pounds per lineal foot per track for the weight of the rails, ties, etc., and adding to it the weight of the floorbeams and stringers per lineal foot. The weight of one floorbeam or stringer is found from the formula $\frac{12\,W l^2 + 2\,R\,l\,d^2}{1.2\,R\,d - 12\,l^2}$, in which l = length in feet, d = depth in inches, R = average flange stress in pounds per square inch, and W = total external load in pounds per square inch, including allowance for impact. In the case of a floorbeam W also includes the weight of two stringers.

By preparing tables of W and W_2 for different lengths, the calculations may be very much simplified.

W_3 is found from the following formulæ:

For plate girders—$W_3 = \frac{(540 + 3.6\,l)\,N}{l}$.

For truss bridges—depths between 12'.5 and 24',

$W_3 = \frac{N\,(336 + 3.2\,l)}{l}$ including upper and lower horizontal bracing. Depths above 24', $W_3 = \frac{N\,(7.5\,l - 180)}{l}$ including upper and lower horizontal bracing and vertical sway bracing, in which N = the number of panels and l = length of span in feet.

Finally we have the formula:

$$W_4 = \frac{W_1 + W_2 + W_3}{\dfrac{3.6\,W\,d}{A + \dfrac{W\,(45\,p^2 + 202\,d^2)}{(W_1 + W_2 + W_3)\,p}} - 1},$$

in which d = depth of truss in feet, and p = panel length in feet.

The numbers 45 and 202 are empirical.

W = numerator of the strut formula used. (For instance in Gordon's formula $\frac{8000}{1 + \frac{l^2}{a\,r^2}}$, W = 8000.)

A is found from the following, N being number of panels.

For single intersection—Pratt:

$$A = p^2\,(2\,N^2 + 3\,N - 2) + 3\,d^2\,(2\,N - 4 + \frac{11}{N}.)$$

For double intersection—Whipple:

$$A = 2\,p^2\,(N^2 + 3\,N - 10 + \frac{12}{N}) + 3\,d^2\,(N - 2 + \frac{16}{N})$$

Also from the given data, the following formula for the total weight of the bridge may be deduced:

$$W_0 = 2(W_2 - 200)\,l + 2\,W_3\,l + 2\,W_4\,l + c.$$

c being the weight of the end shoes, bed plates and rollers.

The live load assumed is the following:

							Tender.				Car.			Car.
15000	15000	25000	25000	25000	25000	15000	15000	15000	15000	12000	12000	12000	12000	12000

Spacings													
9	8	5	5	5	7	5	5	5	4	5	10	5	5

Mr. Pegram's formula: This formula differs from the preceding in that it is entirely empirical, but it is also much simpler, and for ordinary bridges seems to give as good if not better results. The objection to it is that it is not so general in its application. Another advantage claimed by Prof. Du Bois is that his formula depends upon the strut formula used, while Mr. Pegram's does not.

The formula is given for single track and assumes a width of 14 feet in the clear for spans under 255 feet, 18 feet for spans of 320 feet and proportional values between. For double track add 90 per cent. of the weight given by the formula. If safety stringers are used add 100 pounds per lineal foot. Four classes of live loads are given, of which I selected Class T for investigation, as it is given in the Penna. R. R. specifications.

Class T.

16000	12000	24000	24000	24000	24000	16000	16000	16000	16000	3000 per foot.

Spacings									
8	7.5	4.5	4.5	4.5	10.5	5	5.5	5	3

The formulæ are:

For iron bridges under 225 feet span $W = (75 + \frac{s}{a})\,s + s.$

s = span centre to centre of bed plates or end pins.

W = total shipping weight in pounds.

a is a constant depending on the engine distribution. For Class T, $a = 7$.

For iron bridges over 200 feet span $W = (5 + \frac{s}{b})\,s^2.$

$b = 80$ for Class T.

Trautwine's formula for the weight in tons of 2240 pounds of the two trusses per lineal foot is:

For spans under 250 feet $W = \frac{\text{span}}{500} + \frac{\text{square root of span.}}{100}$

For spans over 250 feet $W = \frac{\text{square of span}}{112000} + 0.1.$

For the total weight per lineal foot, assuming the floor 14 feet wide, add 448 pounds per foot for spans under 200 feet and 560 pounds for spans under 300′.

From a number of examples given, I have drawn curves by taking the lengths of span as abscissas, and the corresponding weights as ordinates. *1* Shows the curve for plate girder spans, comparing the actual weight with that given by Pegram's and Du Bois's formulæ, respectively. 2 Shows a comparison of the *total* weights of bridges, and is divided into two parts, the first part for spans up to 100 feet, the second for spans from 100 to 200 feet. The actual weight is compared with that given by Trautwine's, Pegram's, and Du Bois's formulæ, respectively. *3* Shows the actual weight of one truss, compared with that computed from Trautwine's and Du Bois's formulæ. This is also divided into two parts, the first part showing the results for spans between 100 and 200 feet long, and the second for spans between 200 and 300 feet long. Pegram's formula is not adapted to anything but the total weight.

In conclusion, it seems to me from the *given data*, that Pegram's formula would be the most satisfactory for an ordinary style of bridge under ordinary conditions of loading, both on account of its simplicity and the accuracy of the results obtained; but for an unusual condition of loading or method of construction, Du Bois's formula would be likely to give closer results.

W. D. Beatty, '88.

ALUMNI NOTES.

1875.

—The address of F. S. Pecke, C.E., is 16 Winslow Street, Watertown, N.Y.

1878.

—The address of M. P. Paret, C.E., is 1110 Madison Avenue, Baltimore, Md.

1880.

—Abram Bruner, E.M., is Assistant Engineer on the Norfolk & Western Railroad at Lynchburg, Va.

1881.

—T. M. Eynon, Jr., M.E., is again with L. Schutte & Co., Machinists and Engineers, Twelfth and Thompson Streets, Philadelphia, Pa.

1882.

—Eugene Ricksecker, C.E., has recently gone to the Cascade Mountains in Southwestern Oregon, in charge of a topographical party of the U. S. Geological Survey, to begin the work of this season.

1883.

—G. S. Patterson, E.M., has returned to Birmingham, Ala.

—C. L. Rogers, M.E., is the Assistant Manager of the Milton Car Works, Milton, Pa.

—Nelson Morrow, M.E., is the Manager of the Deep Rock Springs at Oswego, N. Y.

—R. R. Peale, B.S., is the Secretary and Treasurer of the Bloomington Coal & Coke Co., 407 Walnut Street, Philadelphia, Pa.

—E. F. Miller, M.E., who has been an Instructor in Mechanical Engineering at the Lehigh University for the past two years, has accepted a position with R. D. Wood & Co., of Camden, N. J.

1884.

—Barry Searle, A.C., intends to open a laboratory at Knoxville, Tenn.

—A. P. Smith, M. E., is an Attorney at Law and Patent Expert, Washington, D. C.

—H. T. Harper, C.E,, formerly on the Lehigh Valley Railroad Engineer Corps at Hazleton, Pa., is now at Tower City, Pa.

1885.

—The address of F. B. Petersen, C.E., is Fort Bowie, Arizona.

—Felix Freyhold, C.E., has been appointed City Engineer of St. Paul, Minn.

1886.

—J. S. Siebert, C.E., is a computer in the Hydrographic Office of the Navy Department, Washington, D. C.

— L. J. H. Grossart, C.E., has established an office as Civil Engineer and Surveyor in rooms 8 and 9 of the Globe Building, Bethlehem, Pa.

—The Twelfth Annual Meeting of the Alumni Association of Lehigh University will be held in Christmas Hall, on the campus, South Bethlehem, Pa., at 14 o'clock, on Alumni Day, June 20th, 1888.

—By referring to the new constitution adopted in April, and published in the last number of the JOURNAL, the price of the JOURNAL will hereafter be $1.00 per annum. We expect to increase its size, and hope that all the alumni, as well as the members of the Society, will coöperate with us in enlarging the usefulness of this periodical.

—The following officers were elected by the Society for the ensuing year at the meeting held May 24: President, J. R, Villalon; Vice-President, L. C. Taylor; Secretary and Assistant Business Manager, A. W. Stockett; Treasurer and Business Manager of the JOURNAL, C. H. Deans; Librarian, C. P. Turner; Editors of the JOURNAL from the Senior Class, A. T. Throop and Pearce Atkinson; Editors of the JOURNAL from the Alumni, H. S. Jacoby, '77, G. F. Duck, '83. The editor from the Junior Class will be elected at the beginning of the next term.

—Prof. Wm. A. Lamberton, M.A., was, on May 7th, elected to the chair of the Greek Language and Literature in the University of Pennsylvania, to succeed the Rev. Frederick A. Muhlenberg, D.D., LL.D., resigned.

The alumni who had the privilege of receiving instruction from him at Lehigh will be glad to know of this recognition of his marked ability. The press in commenting upon this election referred to his high standing among the Greek scholars of America, and of his special teaching power.

We regret that Lehigh University has lost a member of its faculty who for eighteen years has rendered such excellent service in several departments.

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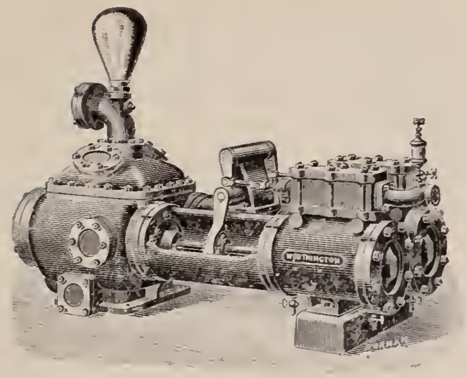

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